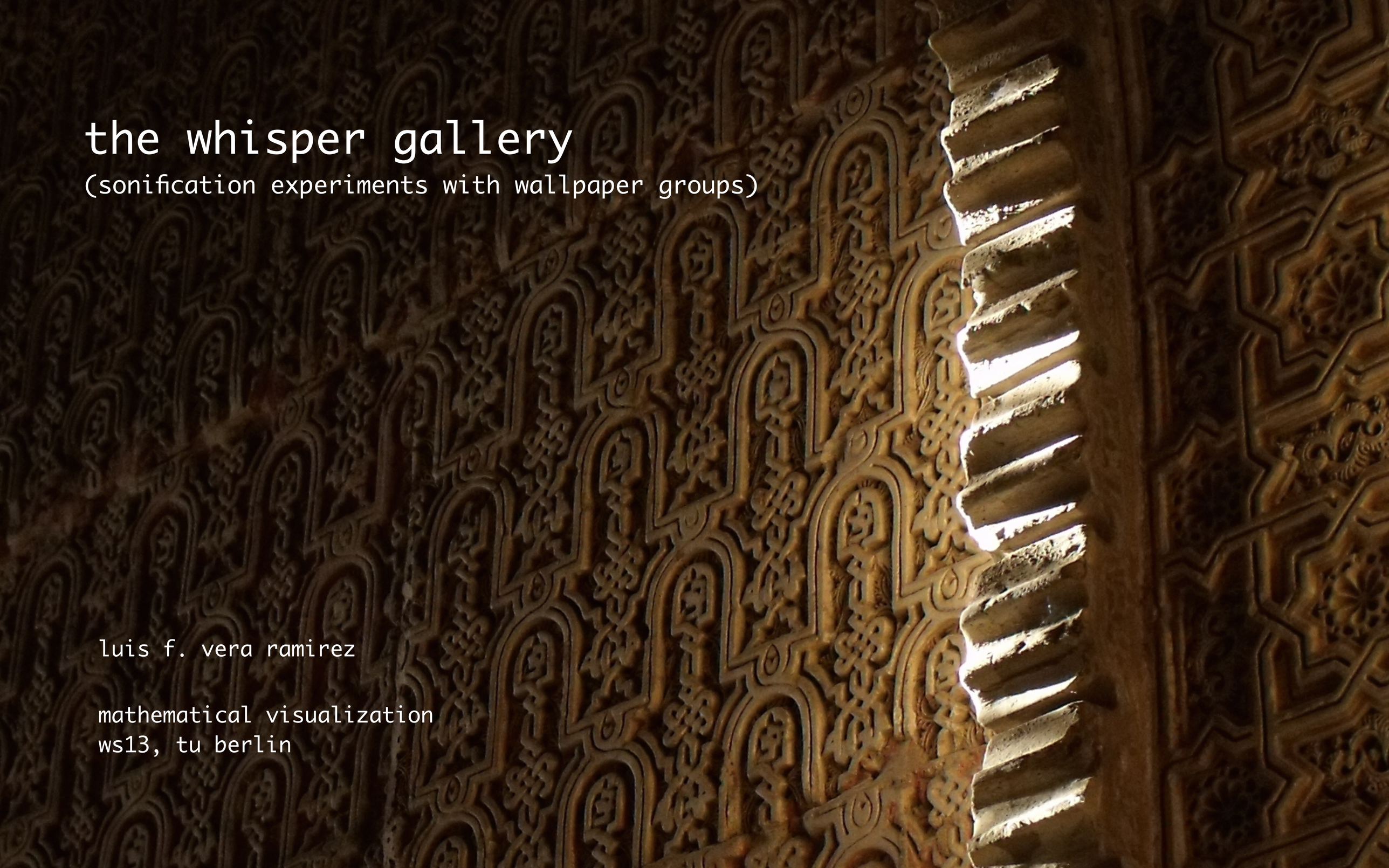
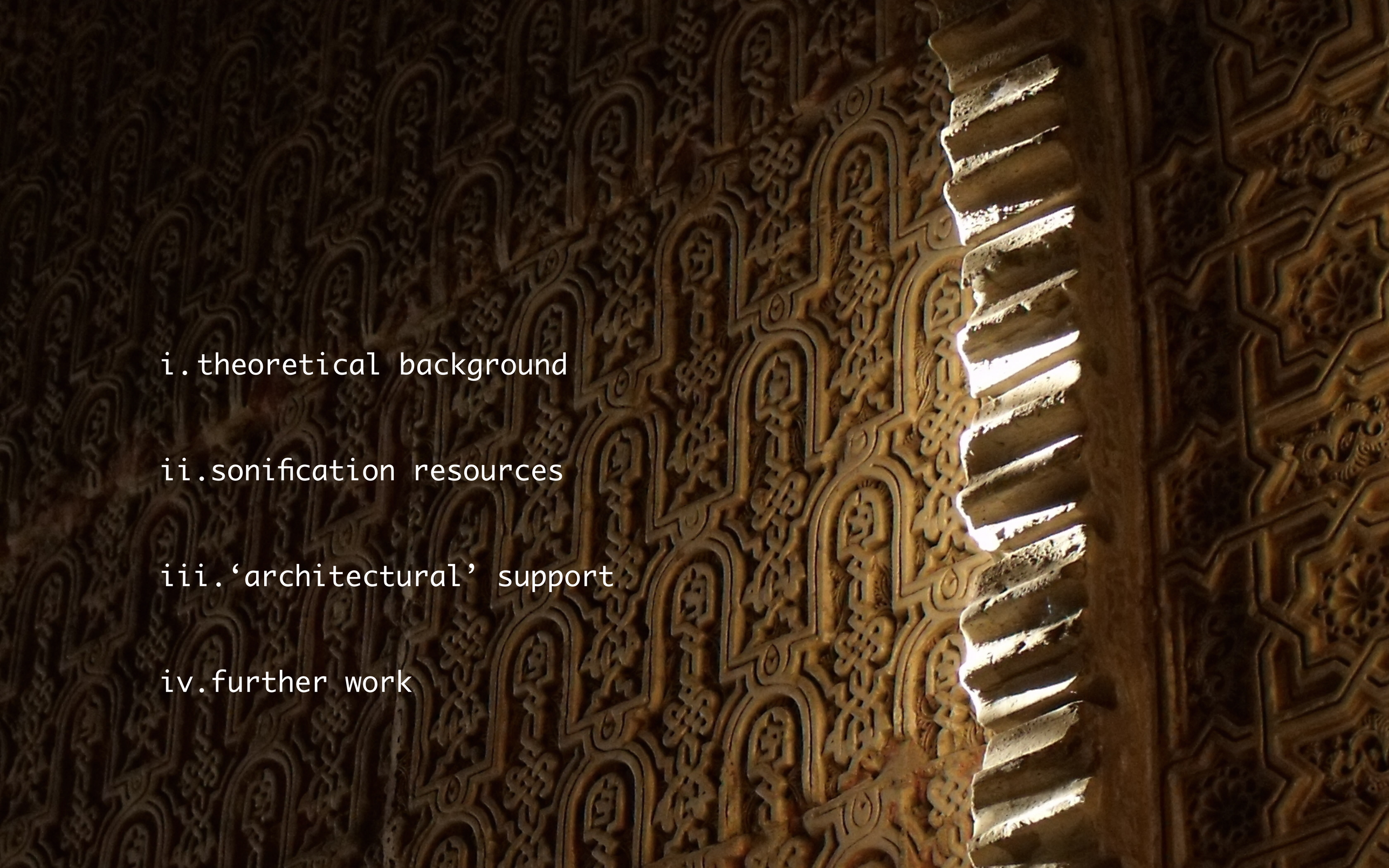


the whisper gallery

(sonification experiments with wallpaper groups)

luis f. vera ramirez

mathematical visualization
ws13, tu berlin



i. theoretical background

ii. sonification resources

iii. ‘architectural’ support

iv. further work

theoretical background

wallpaper groups

"discrete, cocompact (*) subgroups of $\mathrm{Isom}(\mathbb{E}^2)$ up to conjugation in the group of affine automorphisms"

(Symmetry, H. Weyl, 1952)

(*) subgroups whose quotient space $\mathbb{E}^2/G$ is compact

orbifold notation

o, XX, **, *X, 22X,
*2222, 2222, *236, 236, *333, 333, *244, 244,
2*22, 3*3, 4*2, 22*

theoretical background

orbifold

“a space locally modelled on $\mathbb{R}^n$ modulo finite group actions”

(Geometry and Topology of 3-manifolds, W. Thurston, 1980)

theoretical background

orbifold (formal definition)

Def.- An n-dimensional orbifold O consists of a Hausdorff space X_0, with some additional structure. X_0 is to have a covering by a collection of open sets $\{U_i\}$ closed under finite intersections. To each U_i is associated a finite group Γ_i, an action of Γ_i on an open subset $V_i \subseteq \mathbb{R}^n$ (*) and a homeomorphism $\varphi_i\colon U_i \approx V_i/\Gamma_i$. Whenever $U_i \subset U_j$, there is to be an injective homomorphism $f_{ij}\colon \Gamma_i \to \Gamma_j$ and an embedding $\Phi_{ij}\colon V_i \to V_j$ equivariant with respect to f_{ij}.

(Geometry and Topology of 3-manifolds, W. Thurston, 1980)

(*) resp. $V_i \subseteq \mathbb{R}^n$ or $V_i \subseteq \mathbb{R}_+^n$, in the case of orbifolds with boundary

theoretical background

underlying idea of the project

provide the user a real-time experience
(‘sensorial embedding’)
within the two-dimensional
euclidean (*) orbifolds

(*) a two-dimensional orbifold O is called euclidean (or parabolic) if its Euler number $\chi(O)$ is 0; those correspond to the 17 wallpaper groups

sonification resources

sonification (a definition):

"...the transformation of data relations into perceived relations in an acoustic signal for the purposes of facilitating communication of interpretation"

(The Sonification Report, G. Kramer et al., 1999)

sonification resources

sonification (some techniques and applications):

- sonic interaction design (psychological perspective)
- process monitoring (temporally related data)
- statistical sonification for exploratory data analysis; navigation of data and auditory display
- acuoustic sonification (‘spacialization’)

(The Sonification Handbook, edited by T. Hermann et al., 2011)

sonification resources

our approach

we will use the ‘spacialization’ of a sound (i.e. the location of a sound source within the stereo panorama, combined with a proper volume attenuation and, additionally, some frequency modifications) as a resource that reinforces the so-called real-time ‘sensorial embedding’ within the orbifold:

once we live inside this space, we will perceive every word we say repeteadly ‘scattered‘ around us

sonification resources

simplified model for the sound propagation within the orbifolds:

- restriction to a bidimensional model (our ears' and eyes' plane)
- 'linear behaviour' (propagation, reflections, attenuation...) and cardioid diffusion (according to the AudioSource features)
- slow speed of sound (factor 0.1)
- finiteness: we will not hear 'distant' sound sources

sonification resources

under these assumptions, our spacialization model is based on the following analogy:

within an orbifold, the sequence of those reflections and identifications of an individual sound event that finally reach us	$\approx$	in $\mathbb{R}^2$, the sequence of repetitions of an individual sound event which are emitted simultaneously from the (properly directed) ‘orbit of speakers’ (discreteGroup library)

‘architectural’ support

the construction of the orbifold as a sort of ‘room’ whose ‘walls’ reflect and/or transfer every word we pronounce, as well as the underlying presence of the wallpaper groups, refer us to the Alhambra's Islamic palaces in Granada (Spain), where both a whispering gallery and mosaics based on the 17 wallpaper groups (*) can be found

(*) Gruppentheoretische und Strukturanalytische Untersuchungen der Maurischen Ornamente aus der Alhambra in Granada, E.A. Müller, 1944

The four regular mosaics missing in the Alhambra, R. Pérez-Gómez, 1987

Caleidoscopios en la Alhambra, J.M. Montesinos, 1987

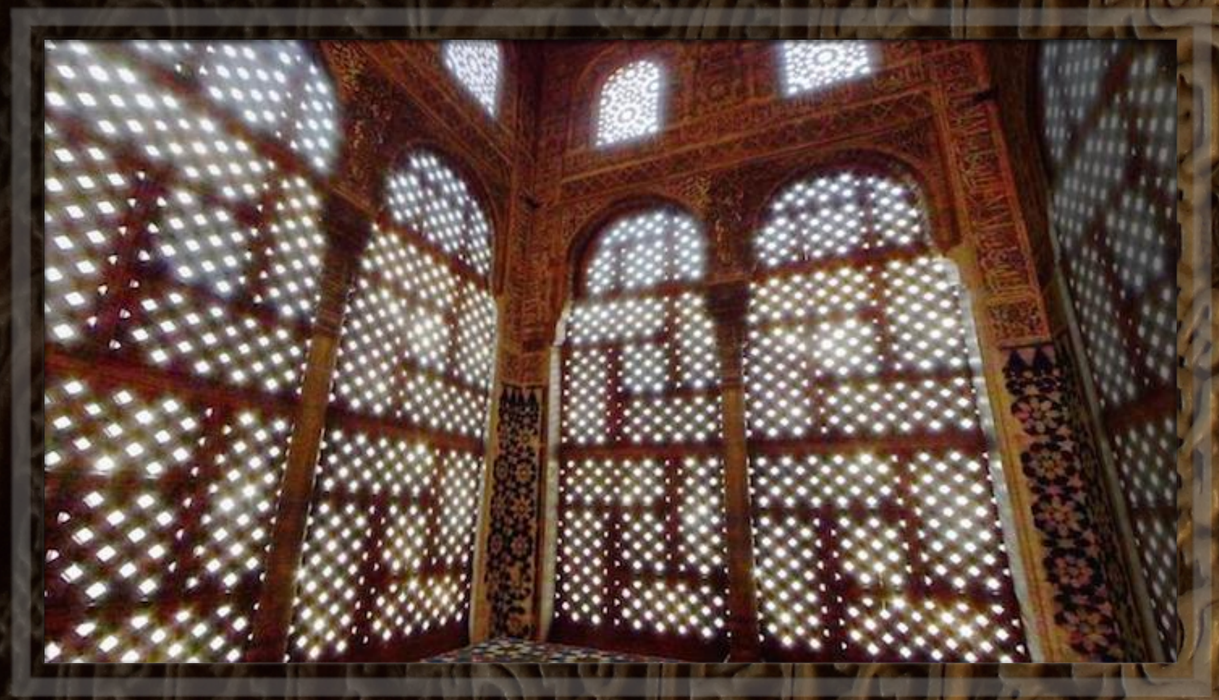
‘architectural’ support

let O be an two-dimensional euclidean orbifold, and let X_0 be its underlying space. we will represent graphically two different ‘underlying structures’ of the orbifold:

- $X_0 \times [0,1] \subseteq \mathbb{R}^3$
- $\mathbb{R}^2 \times [0,1] \subseteq \mathbb{R}^3$, where $\mathbb{R}^2$ is to be seen as the universal cover of O; roughly speaking, the ‘unfolded orbifold’

‘architectural’ support

two ‘architectural’ proposals:



- underlying space (‘unique’ fundamental domain)
  - a room

‘architectural’ support

two ‘architectural’ proposals:

- ‘unfolded space’ (tessellation)
  - a column gallery

further work

- PORTAL implementation
- extension to hyperbolic and spherical orbifolds
- extension to 3D orbifolds
- 'map of the sound' (work in progress)